

Remarks

Status of application

Claims 1-68 were examined and stand rejected over the prior art. After review of the amendments to the claims and Applicant's remarks below, the Examiner's re-examination and reconsideration of the claims are respectfully requested.

The invention

A digital imaging system is described that provides techniques for reducing the amount of processing power required by a given digital camera device and for reducing the bandwidth required for transmitting image information to a target platform. The system defers and/or distributes the processing between the digital imager (i.e., digital camera itself) and the target platform that the digital imager will ultimately be connected to. In this manner, the system is able to decrease the actual computation that occurs at the digital imager. Instead, the system only performs a partial computation at the digital imager device and completes the computation somewhere else, such as at a target computing device (e.g., desktop computer) where time and size are not an issue (relative to the imager). By deferring resource-intensive computations, the present invention substantially reduces the processor requirements and concomitant battery requirements for digital cameras. Further, by adopting an image strategy optimized for compression (using a transformation compressed luminosity record), the present invention decreases the bandwidth requirements for transmitting images, thereby facilitating the wireless transmission of digital camera images.

With this approach, the camera-implemented portion of image processing may forego color processing, including foregoing color interpolation. Instead of performing compute-intensive tasks, such as color interpolations and YUV transformations (Y representing brightness or luminance, and U and V representing degree of colors -- hue and saturation), the methodology performs trivial color plane separation followed by wavelet decomposition, quantization, and generic binary compression (e.g., run-length and Huffman encoding). The end result is that the amount of processing necessary to go from a captured image to a compressed record of the captured image (i.e., a record suitable for storage on the

digital camera) is substantially less than that necessary for transforming the captured image into color and then compressing it into a color-rendered compressed image. Further, the resulting compressed luminosity record, because of its increased compression ratios (e.g., relative to conventional JPEG), facilitates wireless (or other limited bandwidth) transfer of images to target platforms.

Prior art rejections

A. Rejection under 35 U.S.C. Section 102

Claims 21, 23, 28-29, 41, 43-44, 48-49, 61-64, and 66 stand rejected under 35 U.S.C. 102(e) as being anticipated by Acharya et al. (US 6,348,929). Here, the Examiner likens Acharya's scaling technique to Applicant's distributed image processing approach. The Examiner's rejection of claim 21 is representative.

Regarding claim 21, Acharya ('929) disclose a method for scaling of an image, comprising recording sensor information at a first device (the original CFA of the scene 740 captured by the camera 730 are recorded in memory 734, figures 6-7, column 7, lines 20-30); compressing said sensor information prior to color processing, for generating compressed sensor information at the first device (captured images are compressed by an image compression circuit 732, figures 6-7, column 13, lines 35-40); without performing color processing at the first device, transmitting said compressed sensor information to a second device (the compressed images are transferred to computer system 710, figures 6-7, column 14, lines 34-40); decompressing said compressed sensor information at the second device, whereupon said sensor information may thereafter be processed into color image (figure 7, column 14, lines 41-54).

The Acharya '929 reference describes image scaling of the bit planes, not image compression. Further, Acharya image scaling operation is one that dependent on all bit planes, in order to render a scaling that preserves Bayer pattern information. For these and other reasons listed below, it is respectfully submitted that Acharya does not teach or suggest Applicant's invention. Thus, as will be shown below, Applicant's invention is distinguishable on a variety of grounds.

In accordance with Applicant's invention, conventional device-side color process is in fact deferred altogether, such that compressed luminosity information is transmitted instead. In particular, this is made practical by the application of image transformation compression at individual bit planes. In one embodiment, for example, the captured bit planes (e.g., corresponding to R, G, B color planes captured from an RGB mosaic) are separated and compressed using wavelet transform compression. The compressed images are packaged into a single stream with header information to identify the individual bit-streams. The combined bit-stream may then be transmitted to the target device, with a small descriptor of what Bayer pattern should be applied either being transmitted to or being assumed by the target device.

At the outset, it should be understood that image scaling, such as described by Acharya, is not the same as image compression. Although the Acharya reference shows spatial scaling against CFA data (e.g., 4:1 reduction), it is respectfully submitted that application of scaling at that point in image processing does not teach or suggest Applicant's invention. The operation of "scaling" an image is, within the ordinary usage of that term, one of resizing an image, for example, to make the image bigger (scale "up") or to make the image smaller (scale "down"). (See, e.g., Acharya '929 Background Section, at column 1, lines 40-48.). In Applicant's invention, transformation compression (e.g., wavelet transform compression or discrete cosine transformation compression) is performed against the individual bit planes taken from the image sensor (i.e., before color interpolation). This has not been done before in the art, and is certainly not done by Acharya.

Acharya describes a scaling operation that discards image data but preserves a Bayer pattern layouts in the image data, so that color interpolation may be performed on the scaled image data. This is fundamentally a very different operation than transformation compression. For example, when dealing with an RGB pattern (e.g., taken from the image sensor), the prior art approach was to apply lossless compression. In accordance with Applicant's invention, when the R, G, and B bit planes are separated, the image processing system has an opportunity to perform lossy compression. The act or process of sampling and/or discarding portions of the image data (pixel values) set, such as done for Acharya's

scaling, simply reduces the size of the source image. Such sampling or re-sampling techniques are not considered to be compression, as that term is understood in the image processing art.

Still further, spatial scaling itself is completely independent of Applicant's image processing technique. Therefore, Applicant's technique could even be modified to accommodate an additional scaling feature, since such a feature itself is completely independent of the transformation compression that occurs against the individual bit planes using Applicant's technique. The fact that spatial scaling could be added on top of Applicant's approach emphasizes that scaling itself does not provide the transformation compression feature of Applicant's invention, as set forth in the pending claims.

All told, Applicant's invention, as set forth in the pending claims, includes the application of transformation compression against individual bit planes taken from an image sensor (e.g., RGB mosaic). In the prior art, application of such compression technique occurred only after an image underwent color interpolation (i.e., interpolation to full resolution color image using Bayer pattern information). The scaling teaching from Acharya that is cited by the Examiner does not teach or suggest this feature of Applicant's invention. Scaling is not compression but is instead a sampling or re-sampling technique (with or without averaging). The two terms cannot be used interchangeably without regard to their respective underlying meaning.

For the reasons cited above, it is respectfully submitted that a careful review of Acharya shows that that reference clearly does not contemplate anything remotely analogous to Applicant's application of image transformation compression to individual bit planes at the capture device, in order to make distributed image processing practical. Nevertheless, in an effort to expedite prosecution of the present application, the independent claims have been amended to further clarify the above-mentioned features. In view of the deficiencies of the cited reference, and further in view of clarifying amendments made to the claims, it is respectfully submitted that the amended claims distinguish over the art and that the rejection is overcome.

B. First Rejection under 35 U.S.C. Section 103

Claims 1, 3-14, and 18-20 stand rejected under 35 U.S.C. 103(a) as being unpatentable over Acharya et al. (US 6,348,929) in view of Wang et al. (US 5,682,152) further in view of Acharya (US 6,392,699). In this rejection, the Examiner repeats the reasoning applied above (for the Section 102 rejection) by again citing Acharya ('929). However, the Examiner acknowledges that Acharya ('929) fails to specifically disclose applying a wavelet transform, quantization, and compressing (e.g., binary compressing) the luminosity information. Thus, the Examiner turns to Wang for this. Further, the Examiner turns to Acharya ('699) for the teaching of performing color interpolation at the second device.

The claims are believed to be allowable for at least the reasons cited above (for the Section 102 rejection) regarding the deficiencies of Acharya ('929). Further, the Wang reference fails to show application of transformation compression against individual bit planes that comprise recorded luminosity information (e.g., taken from RGB mosaic) in a manner required by Applicant's claims. Moreover, Wang describes application of wavelet transform compression to an image as a whole (and not to individual bit planes comprising luminosity information) and thus, if anything, teaches away from Applicant's approach.

Acharya ('699) does not cure this deficiency, nor does it cure the deficiency of Acharya ('929). And for its part, Acharya ('699) does not teach or suggest Applicant's claim limitation of providing color interpolation at the second device. The claims require (e.g., independent claim 1) "converting said luminosity information at the second device into a color image." This does not simply entail interpolation of Bayer pattern information. Instead, it also entails reversal of the transformation compression previously applied to the individual bit planes that comprise the luminosity information. Acharya ('699) clearly does not provide any such teaching or suggestion.

For the reasons set forth above, it is respectfully submitted that the claims, particularly in view of clarifying amendments made, clearly distinguish over the combined references and that the rejection under this section is overcome.

C. Second Rejection under Section 103

Claims 2, and 15-17 stand rejected under 35 U.S.C. 103(a) as being unpatentable over Acharya et al. (US 6,348,929) in view of Wang et al. (US 5,682,152) and Acharya (US 6,392,699) further in view of Fukuoka (US 5,754,227). Here, the Examiner repeats the above reasoning but then adds Fukuoka for the teaching of Applicant's wireless claim limitation.

The claims are believed to be allowable for at least the reasons cited above pertaining to the deficiencies of Acharya ('699), Acharya ('929), and Wang, whether taken individually or in combination. Fukuoka provides nothing that overcomes these deficiencies. Further, the portion of Fukuoka that the Examiner cited does not support his proposition that Fukuoka teaches or anticipates this claim feature of Applicant's claim. Fukuoka describes transmission of images to AOL using a modem. It does not describe transmission of "compressed luminosity information", as required by Applicant's claim. Therefore, the limitation is not met by the reference. It is respectfully submitted that the claims clearly distinguish over the combined references and that any rejection under this section is overcome.

D. Third Rejection under Section 103

Claims 22, 35-37, 42, and 55-57 stand rejected under 35 U.S.C. 103(a) as being unpatentable over Acharya et al. (US 6,348,929) in view of Fukuoka (US 5,754,227), with the Examiner relying on the previous reason applied above. The claims are believed to be allowable for at least the reasons cited above pertaining to the deficiencies of Acharya ('929) and Fukuoka, and that any rejection to the claims is overcome.

E. Fourth Rejection under Section 103

Claims 24-27, 45-47, and 67-68 stand rejected under 35 U.S.C. 103(a) as being unpatentable over Acharya et al. (US 6,348,929) in view of Wang et al. (US 5,628,152). The claims are believed to be allowable for at least the reasons cited above

pertaining to the deficiencies of Acharya ('929) and Wang, and that any rejection to the claims is overcome.

F. Fifth Rejection under Section 103

Claims 30-34, 50-54, and 58-60 stand rejected under 35 U.S.C. 103(a) as being unpatentable over Acharya et al. (US 6,348,929) in view of Acharya (US 6,392, 699). The claims are believed to be allowable for at least the reasons cited above pertaining to the deficiencies of Acharya ('929) and Acharya ('699), and that any rejection to the claims is overcome.

G. Sixth Rejection under Section 103

Claims 38-40, and 65 stand rejected under 35 U.S.C. 103(a) as being unpatentable over Acharya et al. (US 6,348,929). The claims are believed to be allowable for at least the reasons cited above pertaining to the deficiencies of Acharya ('929), and that any rejection to the claims is overcome.

Conclusion

In view of the foregoing remarks and the amendment to the claims, it is believed that all claims are now in condition for allowance. Hence, it is respectfully requested that the application be passed to issue at an early date.

Appended herewith is an attachment captioned "Version with markings to show changes made" presenting a marked-up version of the changes made to the application by the current amendment. An attachment captioned "Clean-copy Version of Claims" showing all remaining claims, in clean form, is also included. If for any reason the Examiner feels that a telephone conference would in any way expedite prosecution of the subject application, the Examiner is invited to telephone the undersigned at (408) 884-1507.

Respectfully submitted,

A handwritten signature in black ink, appearing to read "John A. Smart", is written over a horizontal line.

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Version with markings to show changes made

In the specification,

Marked-up version of the replacement paragraph(s)/section(s), pursuant to 37 CFR 1.121(b)(1)(iii):

The specification has not been amended.

In the claims,

Marked-up version of the amended claims, pursuant to 37 CFR 1.121(c)(1)(ii):

Claim 1, 21, 41, and 67 have been amended as follows:

1. (Twice Amended) In a digital imaging system, a method for distributed digital image processing, the method comprising:
 - recording luminosity information at a first device, for representing an image that has been digitally captured at the first device;
 - without performing color interpolation at the first device, generating compressed luminosity information at the first device by applying a wavelet transform compression to individual bit planes that comprise the luminosity information, follow by applying quantization[,] and compression to the luminosity information;
 - transmitting said compressed luminosity information to a second device;
 - restoring said luminosity information from said compressed luminosity information at the second device; and
 - converting said luminosity information at the second device into a color image, including performing color interpolation at the second device.

21. (Twice Amended) In a digital imaging system, a method for deferring digital image processing, the method comprising:

recording sensor information from an image sensor at a first device, for representing an image that has been recorded at the image sensor of the first device;
compressing said sensor information prior to color processing by applying a transformation compression to individual bit planes that comprise the sensor information, for generating compressed sensor information at the first device;
without having performed color processing at the first device, transmitting said compressed sensor information to a second device; and
decompressing said compressed sensor information at the second device, whereupon said sensor information may thereafter be processed into a color image.

41. (Twice Amended) An imaging system providing deferred image processing, the system comprising:

an imager having a sensor for recording luminosity information for a visual image captured by the imager, said luminosity information comprising luminosity values recorded by the sensor;

a compressor module for compressing said luminosity information by applying a transformation compression to individual bit planes that comprise the luminosity information, for generating compressed luminosity information at the imager without having performed color processing;

a communication link for transmitting said compressed luminosity information to a target device; and

a decompression module for decompressing said compressed luminosity information at the target device, whereupon said [sensor] luminosity information may thereafter be processed into a color image.

67. (Amended) The system of claim 41, wherein said compressor module comprises a wavelet transform engine for applying a wavelet transform to each individual bit plain that comprises the luminosity information.